Center Innovation Fund: GSFC CIF

Adaptive Trajectory Design (ATD)

Completed Technology Project (2012 - 2014)

Project Introduction

Adaptive Trajectory Design (ATD) is an original concept for quick and efficient end-to-end trajectory designs using proven piece-wise dynamical methods. With ongoing concept designs of Cis-lunar and Earth-Moon libration exploration habitat locations and recently demonstrated by Goddard Space Flight Center support of ARTEMIS, mission design within unstable/stable regions needs the unification of individual trajectories from different dynamical regimes. These trajectories can be developed individually via numerical Floquet methods, high-fidelity integration and optimization, or simple conic applications of a fundamentally elliptical orbit; currently, there is no tool or process that permits the user to blend multiple orbital arcs together into complete designs easily with the exception of our IRAD development. ATD is not subject only to designs where dynamical systems and flow topology have advantages but also to initial injection and arrival orbits. Many upcoming missions and proposals incorporate multiple dynamical regimes and require extensive time to complete an end-to-end design, even though the techniques employed during each phase and within each regime may be the best available.

Mission design within unstable/stable regions needs unification of individual trajectories from different dynamical regimes. NASA needs an automated process to blend multiple dynamical systems to flow topologically different orbital arcs together easily. Develop an automated process which blends single and multi-body trajectory arcs Combine various trajectory design concepts into a unified and continuous path quickly and efficiently End goal is a process and developmental software to blend different types of mission design trajectories We will perform the following: Incorporate additional capabilities for generation of dynamical (Poincaré) maps to assess options and choose the best blend for orbit selection and initial conditions, and capabilities for any sun/planet or planet/moon combination (current algorithms can be reused). Interface ATD with the Goddard Mission Analysis Tool (GMAT) for routine use by the GSFC Navigation and Mission Design Branch. Complete the structure of the algorithm such that future theoretical and technical developments can be easily incorporated. End goal and product is a process and developmental software to blend different types of mission design trajectories into one optimal design. The process will have a theoretical basis but offers an automated structure and, ultimately, with an optimization step incorporated as well. Demonstrate the capability to incorporate trajectory arcs from the following regimes: Earth and Lunar conic; Earth-Moon libration; and Earth-Sun to meet the mission requirements for upcoming missions such as JWST, Earth-Moon libration habitat orbits, and offer a design space for trade-offs. Begin application to other Sun-planet systems, EML2-Mars transfers, Earth-Moon resonant orbit design, and asteroids encounters for OSIRIS applications. Establish ATD as a routine mission design process for efficient combination of various trajectory design concepts into a unified and continuous path. Leverage of a NASA Space Technology Research Fellowship (NSTRF).

Adaptive Trajectory Design

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Anticipated Benefits

ATD represents an innovative next step in trajectory design that will be the future of complex missions for many programs. Once verified and incorporated into GSFC tools, it can be extrapolated to incorporate any other single design methodology.The payoff is equal in support of science, engineering, and the astrodynamics communities at GSFC and all of NASA. ATD impacts science because science investigators are the customers who drive the orbital requirements as well as designs and require original trajectories ideas to enable mission concepts. ATD is a necessity for engineering and astrodynamics and is an important tool in providing optimal trajectory designs to meet these science goals while helping reduce the turnaround time and associated budget.

Outmoded design approaches imply that each section or phase of the design process is completed in isolation and the beginning/end state information from one regime is then used to kick-off the design process in the next regime. Such a serial design strategy is time-consuming and yields a non-optimal result with the very real possibility that the best combination is overlooked. In contrast, ATD allows disconnected arcs to be conceptually devised in different frames (inertial, rotating, libration point) and models (conic, restricted three-body, ephemeris) and then the individual arcs are fused to leverage the advantages of each dynamical environment. As demonstrated by the GSFC support of ARTEMIS EM transfers and libration orbits, mission design within unstable/stable regions needs the unification of individual trajectories from different dynamical regimes. ATD can incorporate designs where dynamical systems and flow topology have advantages that also blend with initial injection and arrival orbits.

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Innovation Fund: GSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Peter M Hughes

Project Manager:

John C Adams

Principal Investigator:

David C Folta

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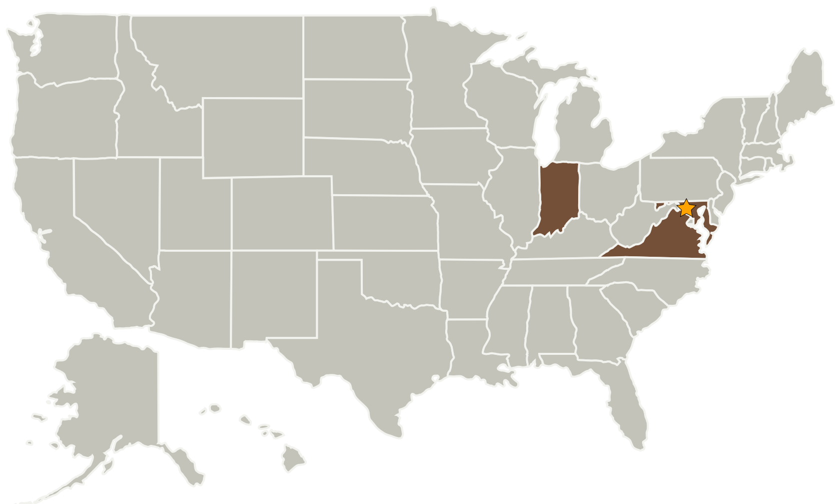
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Co-Funding Partners	Type	Location
Purdue University-Main Campus	Academia	West Lafayette, Indiana

Primary U.S. Work Locations	
Indiana	Maryland
Virginia	

Links

NTR 1
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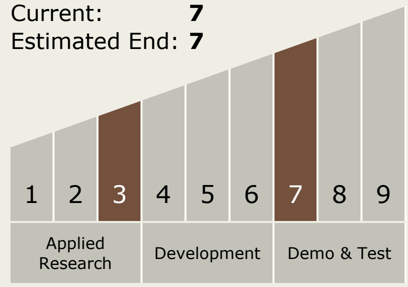
Technology Maturity (TRL)

Start: **3**
Current: **7**
Estimated End: **7**



Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  └ TX17.5 GN&C Systems Engineering Technologies
    └ TX17.5.5 Vehicle Flight Dynamics and Mission Design Tools/Techniques

Project Website:

http://aetd.gsfc.nasa.gov/